

# **Evaluation of NASA's Global Water Cycle Data: Interannual variability, interdecadal changes and trends**

Co-P.I. Michael Bosilovich (NASA GSFC), Co-P.I. Pete Robertson (NASA MSFC)  
Co-I Robert Adler (NASA GSFC)

## **Project hypothesis:**

**Analyzing and verifying the global modes of variability water and energy fluxes in NASA satellite observations, model integrations, and assimilated data can add materially to: (1) improved of understanding critical climate feedback processes, (2) assessing the level of consistency (time-dependent bias, S/N) of current NEWS data sets, and (3) identifying the direction for improving global model physics.**

## **Objectives & deliverables:**

- Determine the modes of variability in net surface heat flux and net freshwater flux including their processes (i.e. latent, sensible, LW, SW, Precip; S/I and longer time scales ).
- Combine analyses of surface fluxes with the TOA flux record and ocean heat storage estimates to improve understanding of climate feedbacks (ENSO,NAO,PDO scales; role of fluxes in teleconnections).
- Identify artifacts existing in current data sets, assess their impact on variability estimates, and interact with NEWS Integration Team to facilitate reprocessing.
- Evaluate models and assimilation tools -- atmospheric reanalyses (MERRA), land data assimilation systems (GLDAS), and fluxes from ocean assimilation systems (e.g. ECCO).

## Technical approach and/or methods:

### Over-arching strategy

- Evaluation of available physical quantities in both observations and models (simulation and analysis)
- Use measurement-rich EOS/CEOP period (2003-2004) for initial assessment of remotely sensed products (e.g. MODIS, TRMM, AMSR, AIRS) and analyses (this period leverages EOS, CEOP links international). Eventually extend along A-Train tenure.
- Cross-ref to historical GEWEX data sets having multi-decadal extent (e.g. GPCP, ISCCP/SRB rad, SSM/I, GSWP / LIS) accounting for sat inter-calibration, other artifacts.
- Reconcile with model/analysis integrations (C20C, MERRA, GLDAS, ECCO)

### Near-term focus

- Intercomparison of current data sets (e.g. NASA/LaRC SRB, CERES Sfc Rad to ISCCP-FD). Issues are sensitivity to near-surface meteorology, cloud forcing.
- Participation in continuation of SEAFLUX activities. What is reality of interannual signals in SSM/I + AMSR-E + TMI. Capabilities of AIRS near surface meteorology.
- Land PBL process validation (e.g. Betts, applied on global grids or on additional observations) Do the relationships apparent in models agree with observations?
- Comparison to MERRA and C20C AGCM output for low frequency study

MGE

### Tools / methods

- Analysis of independent, redundant measurements (e.g. CERES, ISCCP clds and rad; TRMM, SSM/I, QuikSCAT precip);
- Use of CEOP, ARM, TAO/PIRATA buoys, NOAA research cruises as in situ tie points and validation.
- Evaluation of analysis increments in analyses budgets (Schubert et al 96, Bosilovich and Schubert 2001).
  - Use of compositing, lag correlation, EOF/cross-cor matrix techniques, cluster analysis.

## Slide 2

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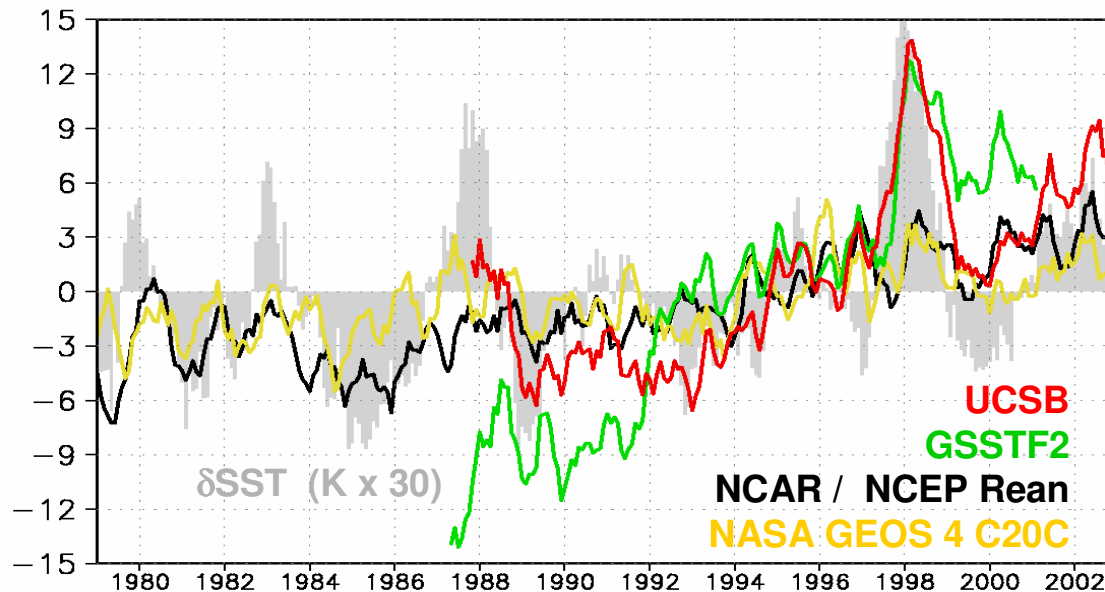
**MGB1**

Remove this bullet?

Michael Bosilovich, 9/7/2005

# Tropical Ocean-Average Latent Heat Flux Anomalies from SSM/I Passive Microwave, NCEP/NCAR and GEOS4

(5-mo running smoother applied)



*How do we explain the large spread in LHF variations and relationship to SST anomalies?*

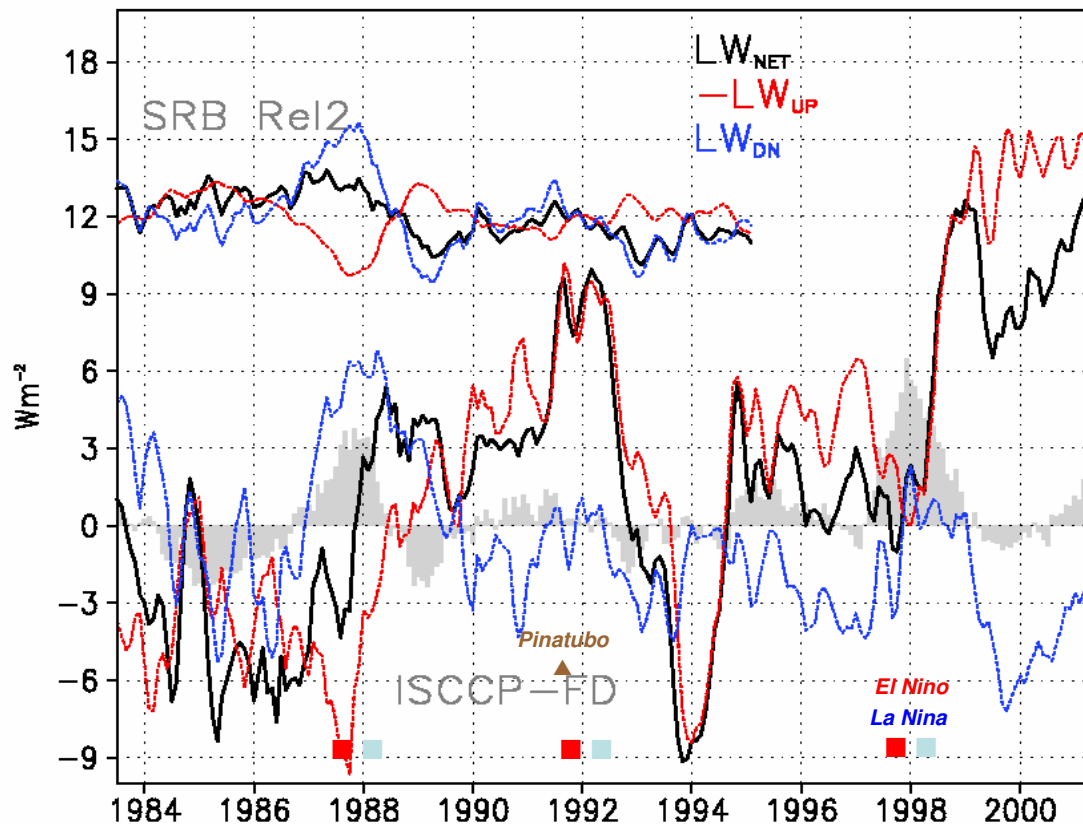
- Both SSM/I LHF estimates have trends substantially larger than model estimates ( $8 - 15 \text{ Wm}^{-2} \text{ decade}^{-1}$  versus  $\sim 3 \text{ Wm}^{-2} \text{ decade}^{-1}$ ).
- After de-trending, satellite sensitivities  $\delta \text{ LHF} / \delta \text{ SST}$  ( **UCSB =  $17.9 \text{ Wm}^{-2} \text{ K}^{-1}$** ; **GSSTF2 =  $6.9 \text{ Wm}^{-2} \text{ K}^{-1}$**  ) remain much larger than for models (NCEP =  $4.3 \text{ Wm}^{-2} \text{ K}^{-1}$ ; GEOS4 =  $4.4 \text{ Wm}^{-2} \text{ K}^{-1}$ ).

# ISCCP-FD and SRB Rel2 Surface Flux Anomalies ( $\text{Wm}^{-2}$ )

$\text{LW}_{\text{dn}}$ ,  $-\text{LW}_{\text{up}}$ ,  $\text{LW}_{\text{net}}$

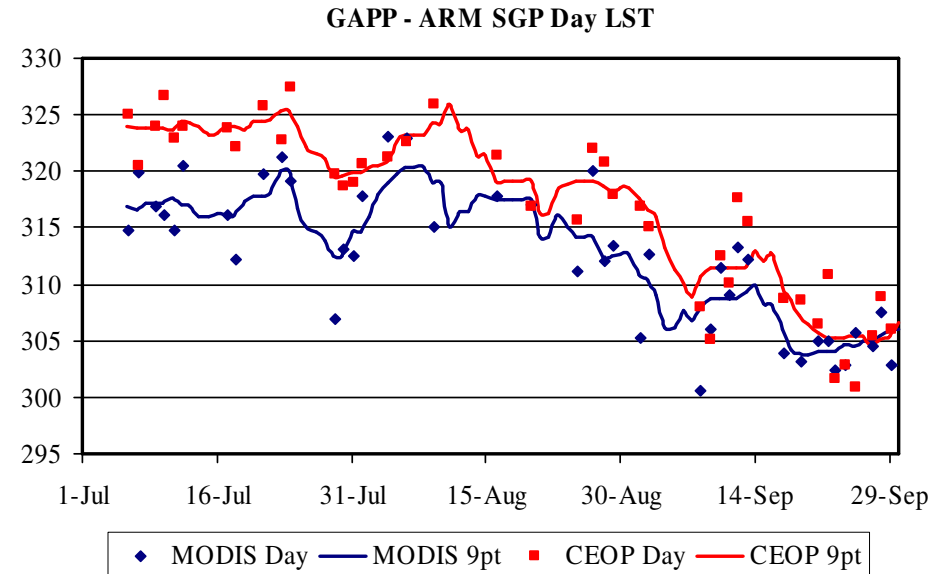
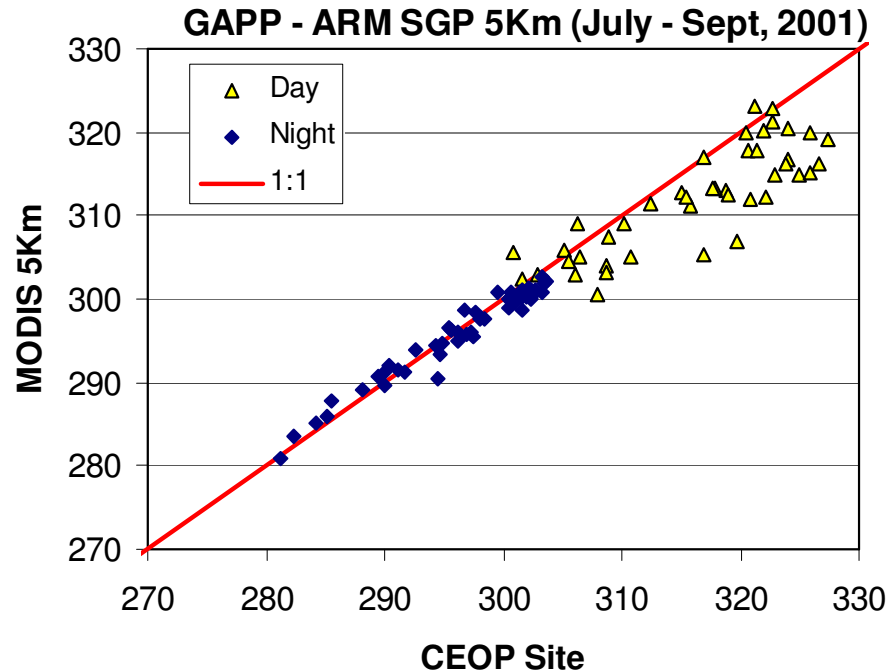
Anomalies are tropical ocean area averaged ( $30^\circ\text{N/S}$ ) monthly departures from Jul 1983 Oct 1995 climatology. Reynolds SST anomalies (K) scaled 10x

(Note: SRB Rel2 fluxes are offset  $+12 \text{ Wm}^{-2}$  for clarity)



- Marked differences in IAV and trends in data sets
- ISCCP  $\text{LW}_{\text{net}}$  trend dominated by  $\text{LW}_{\text{up}}$
- Quality of TOVS meteorology forcing ISCCP at issue
- SRB meteorology essentially model produced (GEOS-1)

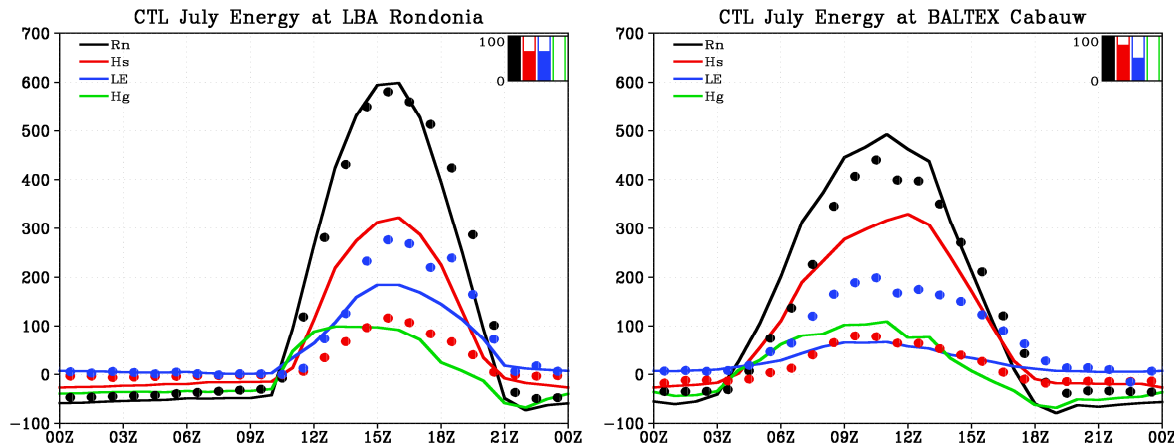
# Observations during CEOP



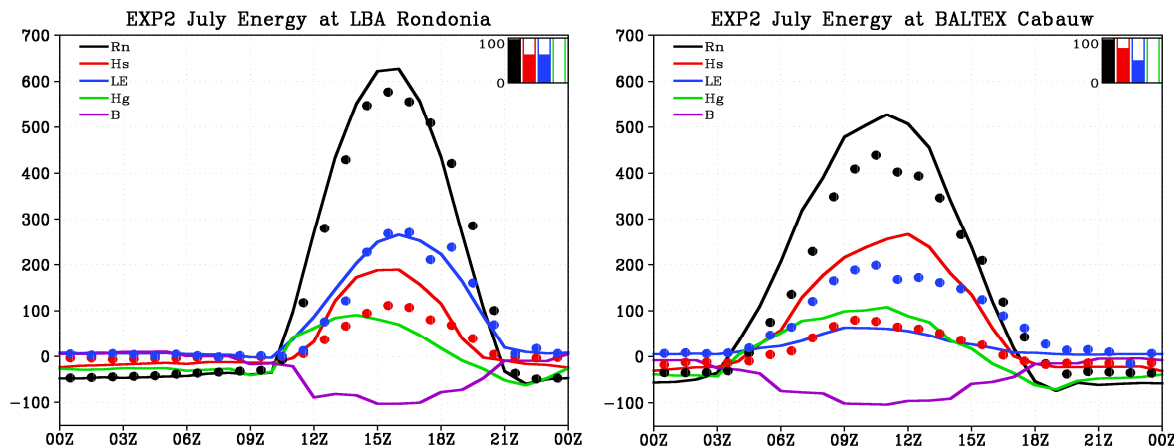
- MODIS – coarse time, fine space
- ARM SGP – fine time, coarse space (point)
- Some seasonal bias noted
- Cloud contamination still apparent

# CEOP Data to Validate Analyses

## Control



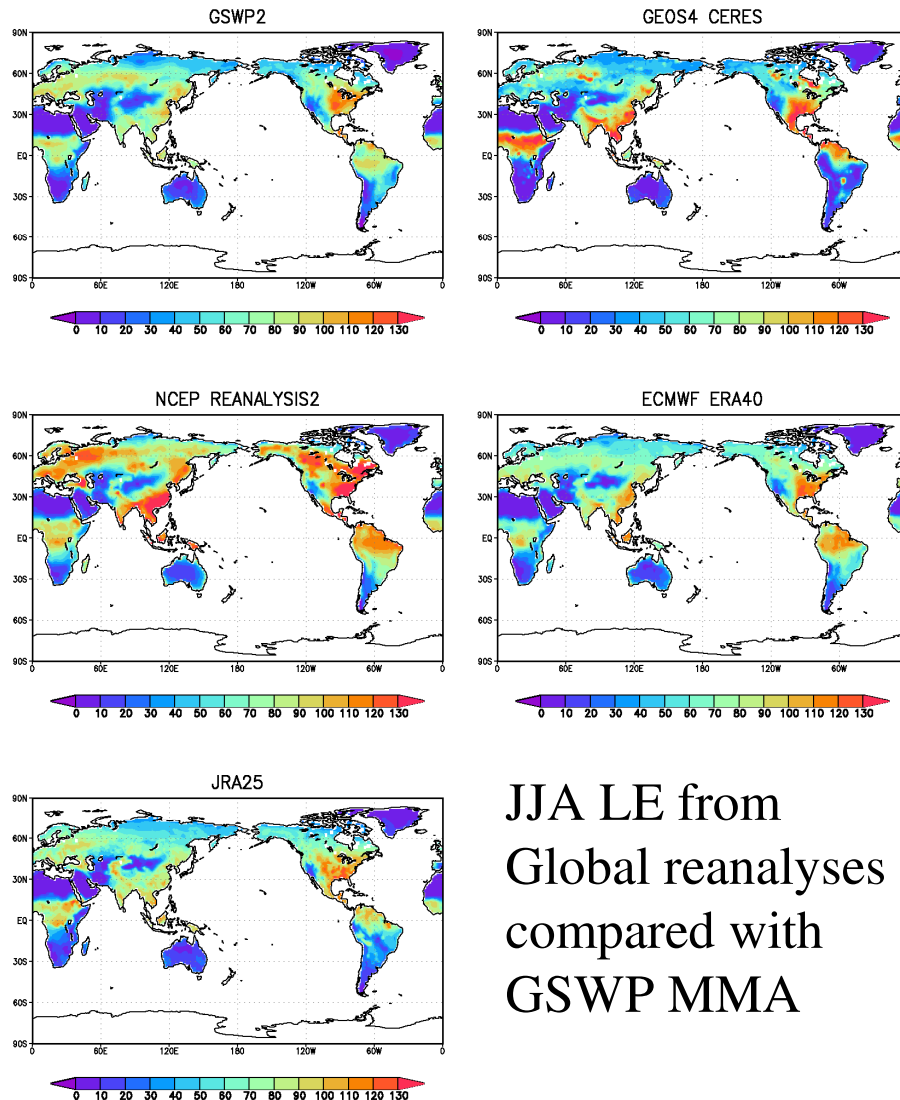
## ISSCP Ts Assimilation



- Coordinated Enhanced Observing Period
- Allows for the intercomparison of analysis data with many global stations and the most advanced satellite data available
- International centers are providing their operational analyses

# Land Processes Study

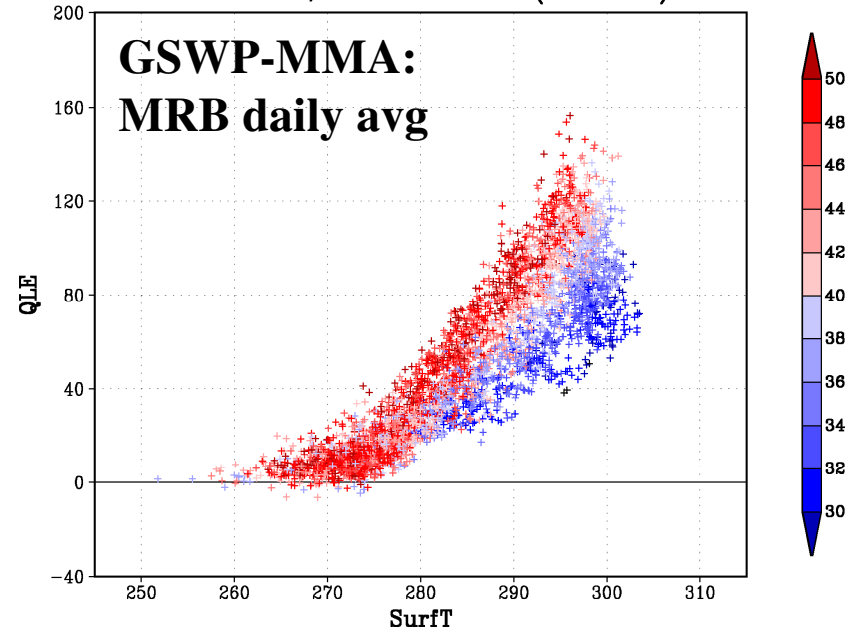
Average Latent Heat Flux 1987–1995 JJA



JJA LE from  
Global reanalyses  
compared with  
GSWP MMA



T and LE, Soil Wetness (% Color)



- Global intercomparisons can be useful
- Need quality observations of simulated variables
- Need to answer why variability exists through process study



**Data set needs** (particularly large data sets – include potential sizes):

- New NEWS-team data products
- Data management: Buy-in from all participants on a data standard (format and grid)
  - Reduce data manipulation manpower and duplication of data sets
  - Climate and Forecasting (CF)? Used by AMIP, CMIP and IPCC
- Flux estimates from pre-EOS, EOS, reanalyses, model exps
- Significant ancillary CEOP observations, some NOAA cruise data, ARM sites, TRMM/ARM variationally constrained analyses

**Project outputs** (project results that may be made available to the NEWS team for subsequent use – include potential size/resource requirements):

- MERRA intercomparison with NEWS data (e.g. GLDAS, GPCP and new data)
- MERRA Water Cycle subset to support NEWS (develop specs with NEWS team input)
- Will develop gridded data sets from level 2 data (specifically for model intercomparisons) through new Goddard DAAC data mining tools (e.g. MODIS TPW and Cloud, eventually land and ocean products)
- Already have an OpenDAP server with several monthly products available (GPCP, GSSTF and NVAP)

**Potential collaborations** (Many due to the globally integrated nature of this project) :

- Famiglietti: Continental water storage E-P
- Adler: GPCP / TRMM precip
- Curry, Liu, Wentz: Ocean turbulent fluxes, moisture transport over ocean
- Rodell/Peters-Lidard: GLDAS/LIS
- Roads, Betts: WEC variations and CEOP data diagnostics
- Soden: Water vapor, cloud feedbacks
- Fetzer: Clouds and water vapor
- Wielicki / Wong: CERES SRB and TOA radiative fluxes
- L'Ecuyer, Olson: radiative flux profiles, LH

**Important outside linkages/resources** (outside the NEWS team) :

- Feed back NEWS team needs, diagnostics and metrics to NASA GMAO operations and reanalysis validation efforts
  - Modern Era Reanalysis for Research and Applications (MERRA)
  - CCSP Reanalysis deliverables
- Collaborations with CEOP model and data groups (CEOP has formed some useful lessons and data resources)
- TRMM/PMM Science Team (Adler/Roberston)
- MODIS Science Team (Bosilovich)

## **Expected contribution to the NEWS objective:**

- Evaluate global dataset adequacy and quality, especially principal quantities such precipitation, evaporation and the water stores (including suggestions for improvements to retrieval and merging algorithms)
- test the water cycle simulation and analysis in models and establish performance metrics for climate simulations and reanalyses
- develop integrated diagnostics to investigate climate forcing and response, (e.g. impact of LoCo on short to long timescales, land data assimilation)
- Long-term: better understanding of the uncertainties in water budgets and closures through algorithm and reanalysis evaluation
- Core data sets open and easily accessible

## **Issues, needs, and concerns:**

- Urge NEWS develop a formalism to drive various algorithms with alternative input data to assess sensitivity; reprocessing even if only limited case study mode (e.g. consistent input meteorology for ISCCP-FD, ocean fluxes, GLDAS forcing).
- Need to explore the possibility of interdisciplinary collaborations with experts in oceanic and cryospheric processes
- While cold processes are not beyond this project, we will not focus on the details
- Data management! (going to have to pay for it) With buy in from NEWS data developers

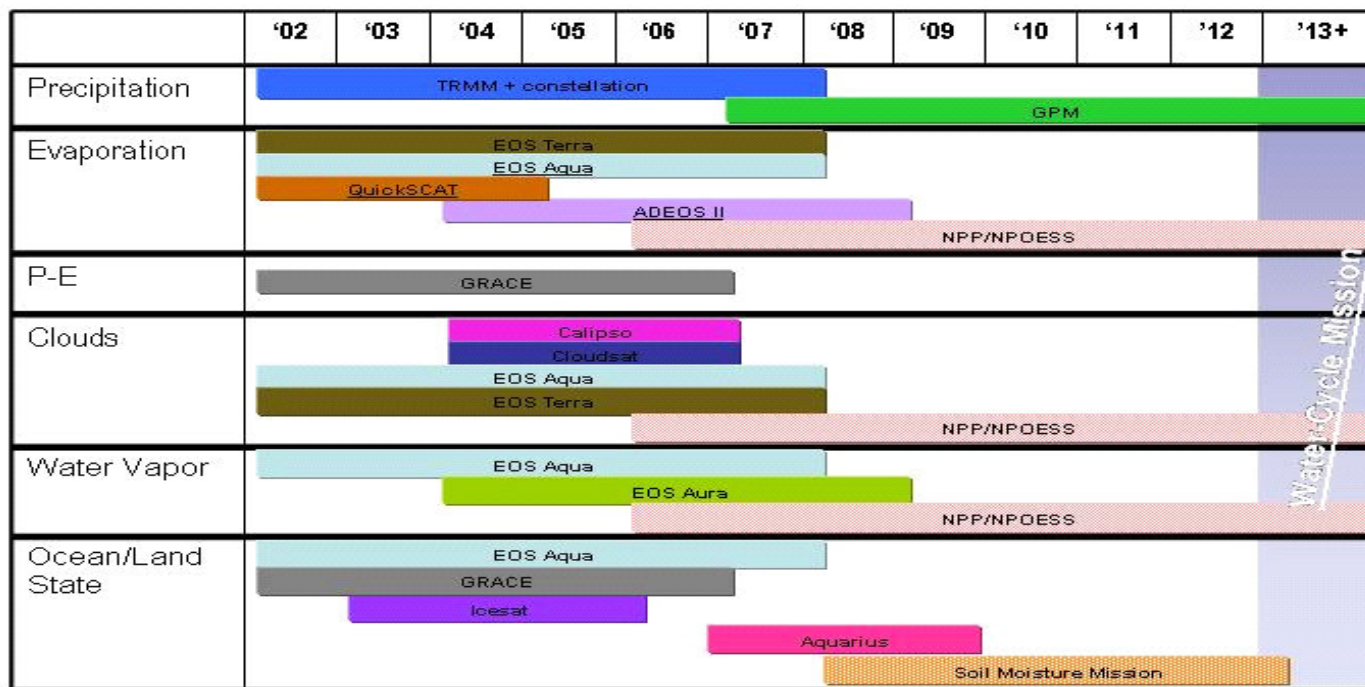


Figure 3: Timeline of water and energy (**need to add them!**) cycle observations from satellite missions.